



Transport Container Standardisation Committee

Transport of Radioactive Material Code of Practice

Guide to the Securing/Retention of
Radioactive Material Payloads and
Packages During Transport

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Foreword

To ensure safe transportation it is essential that radioactive material is adequately restrained within transport packages and that the transport packages are adequately secured to conveyances during transport. This code discusses the main requirements governing tie-downs, provides design criteria for various modes of transport, illustrates typical tie-down systems and makes recommendations regarding operation and inspection. It considers both the replaces the previous issue (September 2014) and has been updated to provide modern restraint methods, incorporate changes from the draft copies of SSR-6 and SSG-26 and correct some minor typographical errors.

1. Introduction

1.1. Scope

This Code of Practice provides guidance on the design and operation of tie-down systems for the restraint of radioactive materials packages and payloads and unpackaged radioactive items. The code covers the following types of packages:

- Excepted package
- Industrial Package (Type IP-1, IP-2, IP-3)
- Type A package
- Type B(U) package
- Type B(M) package
- Type C package
- Unpackaged LSA-I (Low Specific Activity material) and SCO-I (Surface Contaminated Object)

This Code of Practice is based on UK requirements. It does not cover transport in other areas particularly the USA and Japan where different requirements apply.

This Code of Practice is written against draft documentation for updates to both SSR-6 and SSG-26, in advance of their final release.

1.2. Definitions

Attachment point

The attachment point is a fitting on the package to which the tie-down member is secured.

Anchor point

The anchor point is a fitting on the conveyance to which the tie-down member is secured.

Chock

A fitting secured to the conveyance for the purpose of absorbing horizontal forces.

Competent Authority (CA)

The Competent Authority is the national body responsible for enforcing the legal requirements relating to radioactive material packages.

The Competent Authority for the packaging of civil Radioactive Materials in Great Britain is the ONR (Office for Nuclear Regulation). For radioactive material packages used in connection with the UK Nuclear Propulsion and Weapons programmes, the Competent Authority is the Secretary of State for Defence who has delegated authority to the Defence Nuclear Safety Regulator (DNSR).

Conditions of transport

Routine Conditions of transport

Routine conditions are likely to be encountered under everyday/routine operations (i.e. conditions of transport in which there are no minor mishaps or damaging incidents to the package).

Normal Conditions of transport

Normal conditions include events which are undesirable, but common enough to be called mishaps or incidents rather than accidents. These events could produce higher forces on the tie-downs than those expected under Routine Conditions.

Accident Conditions of transport

Accident conditions are where the package is subjected to incidents or accidents of greater severity than those covered by normal conditions of transport.

Conveyance

A conveyance is any vehicle (road vehicle or rail wagon), vessel or aircraft.

Dunnage

Loose packing (e.g. wooden blocks) that does not form part of the radioactive payload or package that is used to restrict movement of the radioactive payload or package.

Payload

The payload includes radioactive contents within a package.

Stillage

A stillage is a framework fitted to a conveyance for carrying one or more unsecured packages.

Stowage

The locating within or on a conveyance of a package containing radioactive material relative to other cargo (both radioactive and non-radioactive)

Tie-down member

The tie-down member is the connecting member (e.g. wire rope, chain, tie-rod, purpose built frame) between the attachment and anchor point.

Tie-down system (or Retention system)

The tie-down system is the assembly of the attachment point, tie-down member and anchor point.

2. Regulations Influencing the Design of Tie-Down Systems

2.1. General Remarks

When a load is secured to a vehicle the motion of the vehicle reacts with the inertia of the load leading to fluctuating stresses in the tie-down system. It is nuclear industry practice to design a tie-down system appropriate for the package and, where appropriate, to provide calculations to justify its suitability.

The IAEA publishes documents that govern tie-down design, the requirements are contained in the Regulations for the Safe Transport of Radioactive Materials, Safety Requirements SSR-6 Draft (Reference 1) and guidance on meeting these requirements is provided in the Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, Safety Guide SSG-26 Draft (Reference 2)

In the UK it is a legal requirement to make sure that all loads carried on road and rail vehicles are adequately secured. The UN Recommendations on the Transport of Dangerous Goods (UNRTDG) and the modal transport regulations which follow from it require that packages containing dangerous goods and unpackaged dangerous articles shall be secured in a manner that will prevent any movement during transport which would change the orientation of the packages or cause them to be damaged.

The conveyance and particularly its load platform must be in a good, clean, serviceable condition and capable of withstanding the induced loads. The package(s) must be orientated such that the centre of gravity is as low as reasonably practical.

The Department for Transport has published a Code of Practice, Safety of Loads on Vehicles (Reference 3) which provides general requirements, basic principles and advice for ensuring that loads are safely transported on road vehicles. This document provides a minimum standard to be achieved for retention of any load, but it advises that for Dangerous Goods extra precautions are necessary. Further advice is contained in the European Best Practice Guidelines on Cargo Securing for Road Transport published by the European Commission (reference 4) and in various publications and regulations regarding transport by sea and air. TCSC has taken these various documents into account and determined a practical set of acceleration values. This Code of Practice provides guidance on the requirements for the carriage of Class 7 (radioactive) Dangerous Goods.

2.2. IAEA Documents

SSR-6 (Reference 1) contains the regulations governing radioactive materials transport. SSG-26 Draft (Reference 2) contains advisory material to help interpret SSR-6. The paragraphs relevant to tie-down design are:

Para 564

Consignments shall be securely stowed.

Para 564.1

The retention of packages within or on conveyances is required for several reasons. By virtue of the movement of the conveyance during transport, small packages may be thrown or may tumble within or on their conveyances if not retained, resulting in their damage. Packages may also be dropped from the conveyance, resulting in their loss or damage. Heavy packages may shift position within or on a conveyance if not properly secured, which could make the conveyance unstable and could thereby cause an accident. Packages should also be restrained to avoid their movement in order to ensure that the

radiation dose rate on the outside of the conveyance, to the driver or to the crew, is not increased.

This explains why packages should be securely stowed.

Para 564.2

Within the context of the Transport Regulations, 'stowage' means the locating within or on a conveyance of a package containing radioactive material relative to other cargo (both radioactive and non-radioactive), and 'retention' means the use of dunnage, braces, blocks or tie-downs, as appropriate, to restrain the package, preventing movement within or on a conveyance during routine transport. When a freight container is used either to facilitate the transport of packaged radioactive material or to act as an overpack, consideration should be made for the packages to be restrained within the freight container. Methods of retention, for example lashings, throwover nets or compartmentation, should be used to prevent damage to the packages when the freight container is being handled or transported. When a freight container or other large box type container is used as a packaging, consideration should be given to the contents to be restrained within the container to prevent damage to the container that might compromise the containment system or shielding integrity under the static and dynamic stresses resulting from handling and routine conditions of transport.

This notes that when a freight container is used as an overpack, the packages within the freight container should be restrained within the freight container. When a freight container or other large box is used as a packaging the contents should be restrained to prevent damage to the container.

Although this paragraph refers to Routine Conditions of transport, a retention system must restrain a package under Normal Conditions of transport.

Para 564.3

For additional guidance on the methods of retention, see Appendix IV.

Para 607

The package shall be so designed in relation to its mass, volume and shape that it can be easily and safely transported. In addition, the package shall be so designed that it can be properly secured in or on the conveyance during transport.

Para 607.1

The design of a package with respect to the manner in which it is secured (retained) within or on the conveyance considers only routine conditions of transport (see para. 613).

This states that only Routine Conditions of transport need to be considered. However, since Normal Conditions of transport includes common mishaps and incidents such as minor impacts, heavy rail shunting, heavy seas and turbulence or rough landings in air transport, a load retention or tie-down system must retain the package under Normal Conditions of transport.

SSR-6 Draft Para 613 which is referred to in Para 607.1 states that the package shall be capable of withstanding the effects of any acceleration, vibration or vibration resonance which may arise under routine conditions of transport. SSG-26 Draft contains the following advice which is relevant to load retention:

Para 613.2

In the case of freight containers used for IP-2, IP-3 or Type A packages that are sufficiently heavy, it is essential to design the container, and the packing or tie-down system of the contents within the container, for the accelerations encountered in routine conditions of

transport. This is to prevent damage to the container caused by the movement of the contained packages that could compromise its containment or shielding integrity.

This effectively repeats the advice in SSG-26 Draft Para 613.2. Again this must apply to Normal Conditions of transport.

Para 609

Attachments and any other features on the outer surface of the package which could be used to lift it shall be designed either to support its mass in accordance with the requirements of para. 608, or shall be removable or otherwise rendered incapable of being used during transport.

Para 609.1

This requirement is intended to prevent inadvertent use of package features that are not suitably designed for handling operations.

If a tie-down attachment could be used to lift a package, this requires that the attachment must either be capable of lifting the whole package or somehow be disabled. Since it is not practical to disable an attachment point, if the attachment point is not suitable for lifting the package, indelible markings on the package, adjacent to the attachment point, should indicate that it must not be used for lifting.

Typically large transport packages require a transport frame or similar to allow attachment to the conveyance. The following paragraph from SSR-6 places requirements on Industrial Package Type IP-3, Type A, Type B(U), Type B(M) and Type C. Tie-down attachment points (typically welded lugs) must not have an adverse effect on the package under normal and accident conditions of transport and therefore shall not impair the ability of the package to comply with the regulations. In essence this means that structural integrity, containment and shielding functions shall not be significantly degraded, such as by tearing or removal of part of the package skin. In addition the requirements of this paragraph are implicated for Fissile packages because of their need to withstand both normal and accident conditions of transport.

Para 638

Any tie-down attachments on the package shall be so designed that, under normal and accident conditions of transport, the forces in those attachments shall not impair the ability of the package to meet the requirements of these Regulations.

SSG-26 Draft provides further guidance on this specifically relating to large packages, stating that in order to show compliance to paragraph 638 a 'weak link' can be designed into the attachment method.

Para 638.1

With the exception of tanks or packages used as freight containers, the securing of packages which have a considerable mass relative to the mass of the conveyance will in general be accomplished using standard equipment suitable for restraining such large masses. Since the retention system 'shall not impair' the functions of the package under normal and accident loading conditions it may be necessary to design the attachment of the retention system to the package so it would fail first (commonly called the 'weak link'). This can be accomplished, for example, by designing the attachment point so that it will accommodate only a certain maximum size of shackle pin, or be held by pins that would shear, or bolts that would break, at a designated stress.

The requirement that the retention system shall not impair the functions of the package means that the forces imposed at the attachment point shall not impair the shielding capacity or containment of the package. This may be achieved by the use of a designed weak-link in the retention system which will fail before the package is damaged. This only applies to package retention systems and not to contents restraint.

Although Paras 638 and 638.1 refer to normal or accident conditions of transport, if a “weak link” is incorporated in the retention system it should only fail under Accident Conditions and must not fail under Normal Conditions of transport. The Package Design must meet all relevant requirements of the regulations when subjected to the forces experienced during Normal Conditions of transport.

The addition of a ‘weak link’ can aid the designer in showing adherence to the regulations specifically relating to accident conditions of transport and remove the need to analyse and/or test the transport frame and conveyance attached to the package during accident conditions of transport. Although the two paragraphs refer to normal and accident conditions of transport, if a ‘weak link’ is incorporated into the tie-down system the strong recommendation is that it should only fail under accident conditions. The preservation of an intact tie-down system following relatively minor incidents in transport is generally preferable for aiding recovery measures, conventional health and safety, and public perception.

Para 638.2

Lifting points may be used as retention system attachments, but if so used they should be designed specifically for both tasks. The separate lifting points and retention system attachments should be clearly marked to indicate their specific purposes, unless they can be so designed that alternative use is impossible, for example a hook type of retention system attachment cannot normally be used for retention purposes.

This allows lifting points to be used as tie-down points, but notes that in some cases it may be necessary to differentiate clearly between the two functions.

Para 638.3

Consideration can also be given to potential directional failure of the retention systems so that the transport workers are protected in the event of head-on impacts, while the package is protected against excessive side loads from side-on impacts [28]. For details on recommended design considerations of packages and their retention systems, see Appendix IV

This suggests that in some cases an argument based on personnel safety may be used to justify the tie-downs failing preferentially in one direction. Additional forward restraint may be used so that a vehicle driver is not injured by the package in an accident. Whatever approach is adopted the release of the package must not occur under Normal Conditions of transport.

SSG-26 Draft Appendix IV

Para IV.4

Package retention systems have to be designed to perform in a predictable manner under all conditions of transport. However, in normal or accident conditions of transport, the package is permitted, and may be required as part of the design, to separate from the conveyance by the breakage or designed release of its restraint in order to preserve the package integrity.

Failure of a retention system under normal conditions of transport as defined in paragraph 3.1.3 of this Code of Practice would not be acceptable. A package must not separate from its conveyance under Normal Conditions of transport nor should the contents move to cause damage to the package during Normal Conditions of transport.

The design intent of a weak link can be difficult to achieve as typically it is difficult to design something to fail at a predictable loading. Further to this it is not possible to hypothesise accident scenarios under which the weak link will fail and the engineer should make a concerted effort to avoid setting out specific accident scenarios to analyse. It is preferential to maintain a hierarchy of failure such that the package is released from its tie-down system

without significant damage to itself and without additional components remaining attached to it. Examples could be to demonstrate that a package shall release from its transport frame before the transport frame detaches from the conveyance. In an alternative system with tie-down members directly from the package to the vehicle, the attachment pins or bolts to the package should be the weakest points in the chain.

Para IV.13

Owing to the differences in transport infrastructures and practices, the national competent authorities and the national and international transport modal standards and regulations need to be consulted to confirm the mandatory or recommended package loads, together with any special conditions for transport, which should be used in the design of the packages. These loads are generally specified by acceleration values to represent the package inertial effects for structural analysis, and are usually applied at the package centre of gravity as equivalent quasi-static forces. The load case data may differ according to the type of structural analysis (strength analysis or fatigue analysis).

Para IV.15

For strength analysis the acceleration values representing routine conditions of transport are given in Table IV.1. The values given in Table IV.1 are derived from different national and international standards and guidelines (Refs [IV.1, 2, 3, 6, 8, 14, 27, 29, 31]), using a factor of about 1.25 that increases the confidence that the proposed range of loading will not be exceeded. Use of these acceleration values would generally be good practice but for ground transport in some transit facilities different values may be relevant (e.g. handling of packages at an airport). If a specific design code is used in the analysis, an additional safety factor consistent with the applied code may be required. If no specific design code is used, then a safety factor should be considered and justified in the analysis (see for examples Ref [IV.36]). The forces imposed on the package are determined by multiplying the acceleration values listed in Table IV.1 by the mass of the package and are applied at its center of gravity. The analysis should first consider application of each directional acceleration value separately and then all combinations for each line in Table IV.1 for the relevant transport mode.

Table IV-1 lists suitable acceleration factors. A further table, Table IV-2 lists other figures that have a more specific application to country, region or mode of transport. TCSC has taken various national and international standards and guidelines into account and determined a practical set of acceleration values.

If the acceleration factors from SSG-26 Draft are used, stresses in steel components forming part of the package or contents restraint system should not exceed the yield stress for that material.

2.3. United Nations Recommendations on the Transport of Dangerous Goods

The UN Recommendations on the Transport of Dangerous Goods (UNRTDG) (Reference 5) form the basis for regulations governing the transport of dangerous goods including radioactive materials.

Para 7.1.1.8

Packages containing dangerous goods and unpackaged dangerous articles shall be secured by suitable means capable of restraining the goods (such as fastening straps, sliding slatboards, adjustable brackets) in the cargo transport unit in a manner that will prevent any movement during transport which would change the orientation of the packages or cause them to be damaged.

NOTE

Additional guidance on the packing of cargo transport units can be found in the IMO/ILO/UNECE Guidelines for Packing Cargo Transport Units (CTUs) contained in the supplement to the International Maritime Dangerous Goods Code. Modal and National Code of Practice (such as the Agreement governing the exchange and use of Wagons between Railway Undertakings (RIV2000) Appendix II loading guidelines published by the International Union of Railways (UIC) or the United Kingdom Department for Transport Code of Practice on Safety of Loads on Vehicles) may also be available.

This forms the basis for the acceleration factors used in Table 2 of this Code of Practice which are based on the additional guidance referred to.

2.4. Competent Authority Guide

Type B(U), Type B(M), Type C and all fissile package designs must be directly approved by the Competent Authority (CA). The contents of the applicant's safety documentation is specified by SSR-6 Draft. This document demands that to obtain design approval from the CA a package must be shown to comply with the requirements of SSR-6 Draft and gives the format in which evidence supplied in support of an application is to be presented. Part II, section 4.2 deals with tie-down (or retention) systems.

Type A, Industrial and Excepted packages which do not require Competent Authority approval are granted local approval through compliance certification. The requirements of SSR-6 Draft apply, though the actual method of approval may vary in different organisations. See TCSC 1078 (Reference 7) for further details.

2.5. Summary of the Main Requirements

To summarise the requirements of the controlling documents:

- Packages shall be properly secured in or on the conveyance during transport.
- Contents shall be restrained in Packages during transport
- A tie-down system must not reduce the effectiveness of the package under any circumstances.
- A tie-down system must not fail under Routine or Normal Conditions of Transport.
- A tie-down system is permitted to fail if required by the design under Accident Conditions of transport so that the package integrity is not compromised.

When considering strength analysis the quasi-static accelerations act simultaneously as indicated in

Table 1. Fatigue shall be considered. For fatigue analysis the quasi-static accelerations act in all three directions simultaneously.

3. General Design Parameters for Package and Contents Restraint Systems

3.1. Conditions of Transport

Routine and Normal Conditions of transport apply loads to a tie-down system throughout its useful life without failure until it is terminated by either:

- encountering Accident Conditions
- wearing out
- exceeding some pre-determined life span
- failing to satisfy new regulations

3.1.1. Routine Conditions of Transport (RCT)

Under Routine Conditions of transport stresses in the tie-down system will arise from inertial forces as a result of:

- uneven surface
- vibration
- speed variations
- direction changes
- road skids that do not result in impact

Routine conditions of transport typically capture loads that would be considered under fatigue analysis.

3.1.2. Normal Conditions of Transport (NCT)

The tie-down system may experience higher loads when subjected to Normal Conditions of transport arising from minor mishaps or less common occurrences such as:

- heavy braking
- minor impacts with vehicles and obstacles
- heavy rail shunting
- heavy seas
- turbulence or rough landings in air transport.

Normal conditions of transport typically capture loads that would be considered under strength analysis.

3.1.3. Accident Conditions of Transport (ACT)

Accident Conditions of transport apply loads to a tie-down system in excess of those found under Normal Conditions of transport. Typically these arise when the conveyance or package is subjected to a violent impact.

For larger packages a weak link (Section 0) could be considered to remove the need to analyse the tie-down system and transport frame during accident conditions of transport.

3.2. Modes of Transport

A loaded package may be restricted to certain modes of transport as specified on its Certificate of Approval. In designing a suitable tie-down system all relevant modes of transport must be considered. It may be that differing tie-down systems will be necessary for different modes of transport.

Where a weak link is included in a multi-modal transport tie-down system it may be necessary to have a weak link component that can be swapped as required based on the different accelerations that would be seen under the different modes of transport.

3.3. Methodology

It is common practice to calculate stresses in a tie-down system by assuming values of acceleration applied to the package in the longitudinal, lateral and vertical directions (relative to the axes of the conveyance) then converting them to forces acting on the tie-down system through the package centre of gravity by multiplying the acceleration values by the mass of the package. Due to the fact that accelerations are not applied simultaneously (see

Table 1: Acceleration factors for package retention system design (Strength Assessment)), a number of different strength analyses may be required to capture the various loads that may be applied to the tie-down system during NCT. A tie-down system generally comprises three components (see Figure 1). These are: the attachment point, the tie-down member, and the anchor point. Each component shall be assessed for strength (see

Table 1: Acceleration factors for package retention system design (Strength Assessment)) and fatigue performance Table 2: Acceleration factors for fatigue assessment

Loads in a tie-down system are calculated as follows:

- Determine the analysis to be undertaken and the appropriate acceleration factors that will be applied from
- Table 1: Acceleration factors for package retention system design (Strength Assessment)
- All accelerations are in "g" and must be multiplied by 9.81 to convert to m/s^2 . Use the values for the correct mode of transport or otherwise permitted by modal authorities or competent authorities.
- Determine the design code that will provide allowable stresses for analysis of the stresses derived from the accelerations. Alternatively as stated in Appendix IV a safety factor may be considered. *Note: The method should be agreed with the Competent Authority.*
- Obtain the force in each direction by taking the product of the acceleration factor and the package mass, i.e.: Load (Newtons) = Acceleration factor (g) \times 9.81 (m/s^2) \times mass (kg)

Section 4 illustrates typical tie-down systems and offers suggested methods for finding the load in some common arrangements of tie-down system.

If necessary, it is recommended that the designer consults the Competent Authority or the relevant Approval Authority for packages not subject to Competent Authority approval at an early stage to agree the approach to be used.

The design code accepted for assessing steel items in tie-down systems is BS 2573 Rules for the design of cranes (Reference 8). (BS 2573 will be replaced by BS EN 13001 when all

parts are published). Advice on methods for calculating loads in lugs may be found in TCSC 1079 (Reference 9).

Inland Waterways: The IMO (International Maritime Organization) guidelines (Reference 11) state “Inland river and waterway transport is generally smooth. It will not normally exert any forces higher than those of road transport on the cargo and the CTU (Cargo Transport Unit)”. Factors for road transport may therefore be used.

The analysis should first consider application of each directional acceleration value separately and then all combinations for each line in Table 1 for the relevant transport mode.

Table 1: Acceleration factors for package retention system design (Strength Assessment)

| Mode of Transport | Acceleration Factors Applied to the Package | | |
|-------------------|---|---------|-----------------------|
| | Longitudinal | Lateral | Vertical |
| Road | 1g | - | 1g down, $\pm 0.3g^2$ |
| | - | 0.7g | 1g down, $\pm 0.3g^2$ |
| Rail | 1.3g/5g ³ | - | 1g down, $\pm 0.4g$ |
| | - | 0.7g | 1g down, $\pm 0.4g$ |
| Sea/Water | 0.5g | - | 1g down $\pm 1g$ |
| | 0.3g | 1g | 1g down $\pm 0.6g$ |
| Air | 1.3g ⁴ | - | 1g down |
| | - | 1.3g | 1g down |
| | - | - | 2.5g up, 2.5g down |

1. The effect of gravity is included.
2. For packages transported in vehicles lighter than 3 500 kg, higher acceleration values should be considered
3. 1.3g should be used if wagons equipped with long-stroke shock-absorbers or if hump and fly shunting operations are explicitly excluded. Hump and fly shunting is no longer accepted practice in the UK.
4. Forward restraint of the load to 9g is required in the cabin main deck if there is no 9g crash net or stressed bulkhead installed between the load in the cabin/main deck and the passengers and/or crew.

Table 1 incorporates acceleration factors which have been determined based on Appendix IV of SSG-26 Draft. The Appendix also provides acceleration values for specific packages. These can be found in Table IV.2 of Appendix IV of SSG-26 Draft.

3.4. Fatigue

When appropriate the fatigue of metal components of the tie-down system should also be considered. Relevant design codes or standards should be used. Guidance for fatigue assessments may be taken from BS EN 1993-1-9 (Reference 12) or BS 7608:2014 (Reference 13). It may be necessary to consider accumulated fatigue damage across the various modes of transport throughout the expected life.

For road and rail transport the predominant forces are those in the vertical direction, the frequency depending upon the vehicle suspension and the ratio of laden to unladen mass. For various configurations of road transport the following natural frequencies (f_n) can be used as a guide:

- Steel Sprung Suspension 3 Hz
- Air Suspension 1.5 Hz

Further guidance for rail transport may be found in GM/GN2688 (Reference 15), GM/RT2100 (Reference 16) and BS EN 15663:2017 (Reference 17).

It is intended that the acceleration factors provided in Table 2: Acceleration factors for fatigue assessment shall be used to calculate forces on the tie-down system during usage. These forces can then be used to analyse components against the proposed fatigue codes, with the design either aiming to achieve a design life below the endurance limit or a limited design life based on the estimated number of miles travelled and the frequencies proposed above.

Table 2: Acceleration factors for fatigue assessment

| Mode of Transport | Acceleration Factors Applied to the Package | | |
|-------------------|---|---------|----------------|
| | Longitudinal | Lateral | Vertical |
| Road | ±0.2g | ±0.2g | 1g down ±0.3g |
| Rail | ±0.3g | ±0.4g | 1g down ±0.3g |
| Sea | ±0.12g | ±0.55g | 1g down ±0.35g |

1. The vertical factors listed in Table 2 include the effects of gravity

Note: All acceleration values for fatigue will apply in all directions thereby providing a stress range for comparison to the fatigue design code.

Road: Based on RAMTRANS paper, Package Tie-downs – A Programme of Measurement and Assessment (Reference 10) which reports on a series of transport studies. The vertical values are based on a study during the move of a fragile piece of equipment in the US (Reference 18).

Rail: Based on Appendix IV of SSG-26 Draft.

Sea: Based on RAMTRANS paper, Flask Tiedown Design and Experience of Monitoring Forces (Reference 19).

4. Design of Specific Tie-Down Systems

4.1. General Remarks

Since radioactive material packages are frequently not only heavy but also dense, they can act almost as a point load on a vehicle bed. In some situations it may be necessary to provide a load spreading frame so that the vehicle bed is not locally over stressed or so that permitted axle loadings are not exceeded.

Consideration should be given to preparing a loading plan with instructions for positioning the package(s) and tie-down arrangements for securing the package(s) to the conveyance.

4.2. Anchor Points

Anchor points must always be placed so that there is a load path into the conveyance primary structure. If modifications to the conveyance structure are required, the manufacturer must be consulted before they are implemented. This particularly applies to road trailers if the longitudinal members are to be drilled or welded and to ancillary equipment such as transport frames, ISO containers and ISO platforms (flat racks).

When required any modification shall be referred to an appropriate approval body.

4.3. Types of Package Tie-Down System

Tie-down systems may be divided into seven broad categories, as follows:

Trunnion

Trunnions on the package are secured to bearers that are either on a transport frame or form part of the vehicle. See Section 4.4

Corner ties

Lashings are connected between attachment points on the package and anchor points on the bed of the conveyance. See Section 4.5.

Directly bolted

The package is bolted either to a transport frame or directly to the conveyance. See Section 4.6.

ISO twistlocks & UIC Spigots

UIC Spigots - Used with corner fittings as a tie-down system for ISO freight containers or for transport frames that mimic these. UIC Spigots are a singular solid restraining device designed to prevent an ISO freight container from tipping while providing conventional restraint. They can be either pinned or unpinned to the body of the conveyance. See Section 4.7.

ISO twistlocks - Used with ISO corner fittings as a tie-down system for ISO freight containers or for transport frames that mimic these. Twistlocks are a restraining device with a central rotating pin which locks the ISO freight container to body of the conveyance. See Section 4.7.

Over Strapping

Lashings are positioned over the top of the package and secured to the vehicle. See Section 4.8

Self retaining

The package is retained under its own mass in a stillage or a well. See Section 4.9

Unsecured

The package is carried loose inside an enclosed vehicle. See Section 4.10.

The following sections discuss the design of each of these systems in turn.

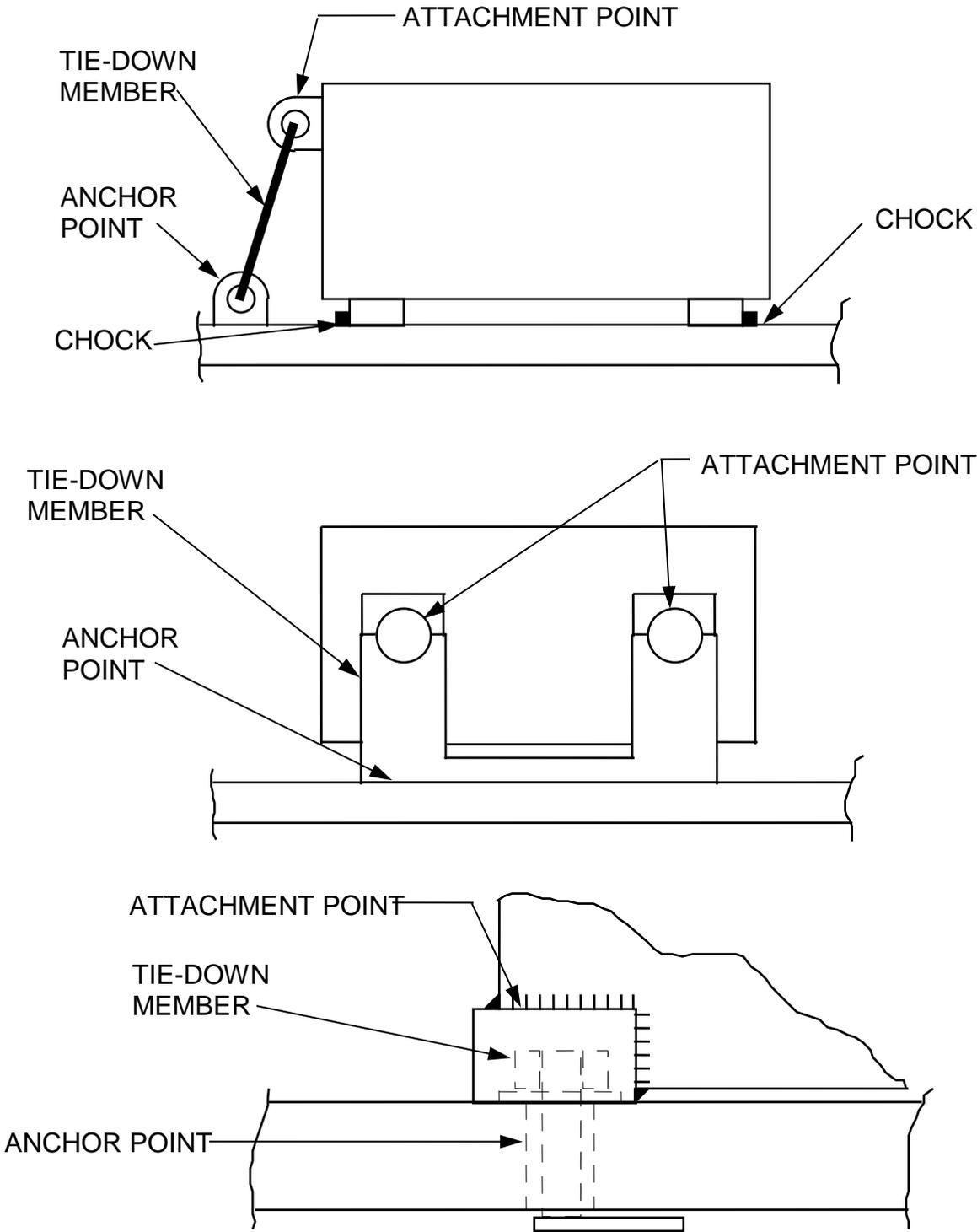
4.4. Trunnion

Trunnions are categorised as attachments and the trunnion bearers as tie-down members, see Figure 1. Trunnions may be welded to the package, though current practice favours a bolted connection since this makes in-service inspection easier. Unless the trunnion bearers are unusually deep it is advisable to secure the package with bolted trunnion caps. Calculation of design stresses is conventional; bending and shear within the trunnion and consequent stresses in the welded or bolted attachment must be considered. Care must be taken when deciding on the design loads. To give a conservative case the total load (package mass \times the appropriate acceleration) should be distributed between not more than two trunnions. In the case of very heavy packages this may lead to over design and make it difficult to accommodate the trunnions on the packaging. In this case, provided that the alignment between the trunnions and trunnion bearers is good, it is possible to claim credit for torsional flexure of the conveyance and consequently make a case for load sharing over three or more trunnions.

Trunnions are frequently used for lifting and rotating the package as well as supporting it during transport. It is generally found that the loads due to lifting are more severe than those arising during transport. However, the designer must exercise care and ensure that all possible load cases are considered. This situation arises most notably with spent fuel flasks, in which fatigue is a particularly sensitive issue. Fatigue failure becomes more likely if a trunnion's surface becomes damaged, so it is advisable to fit low friction material (such as aluminium bronze) in the trunnion bearers.

For further information see BS ISO 10276:2010 Trunnions for packages used to transport radioactive material (Reference 20).

Figure 1: Examples of tie-down systems



4.5. Corner Ties

4.5.1. Cuboidal Packages

This system is shown in generalised form in Figure 2. It is strongly recommended that the package is chocked in all directions. The ties should be pre-tensioned to reduce shock loading and fatigue damage.

The tension in the tie-down members can be calculated using standard or BS EN 12195-1 (Reference 21) or from first principles by a suitably qualified engineer.

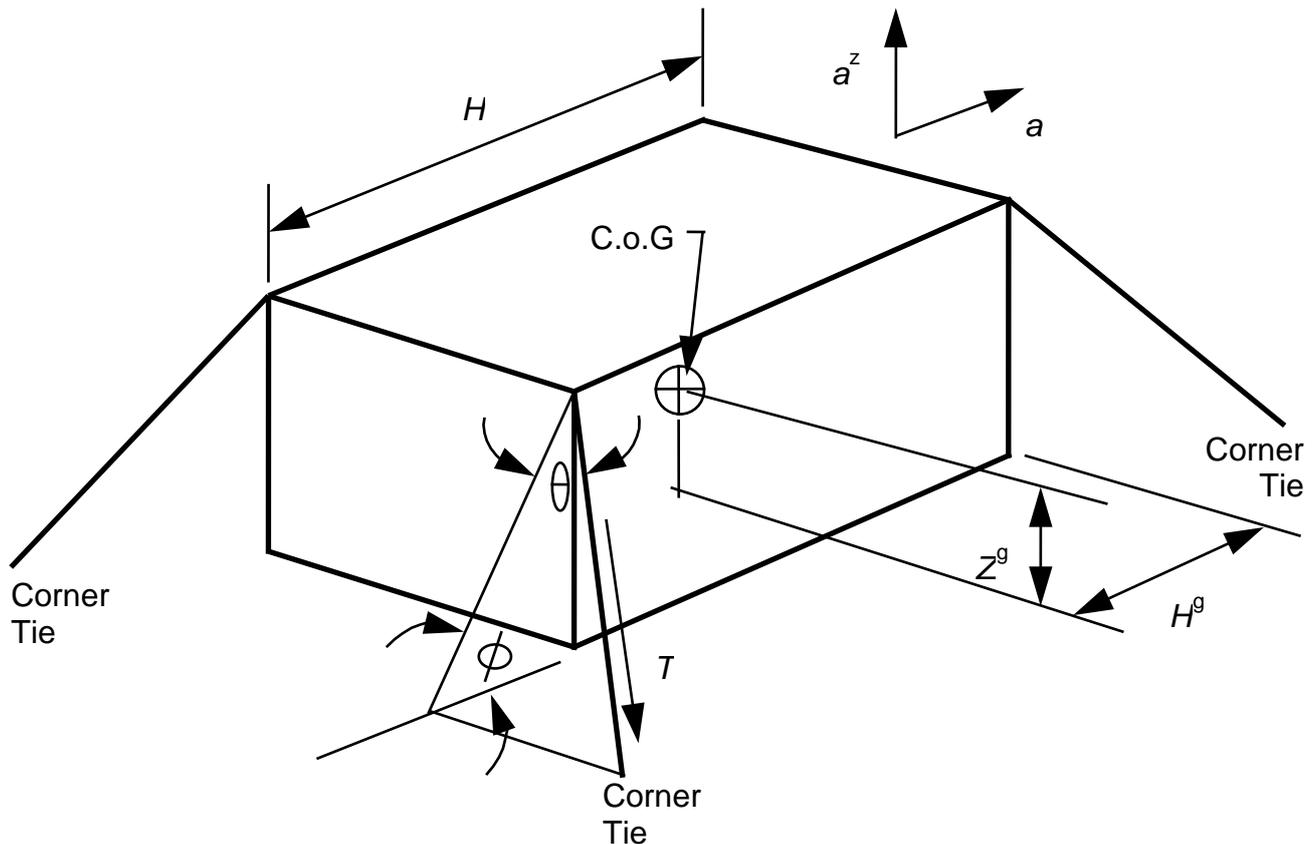
Since a package will only tip in one direction and since there is no resulting additional tension in a tie-down member until the package is on the point of tipping, the only forces that need to be considered are those in the direction of tipping.

When chocks are used the resultant force on the chock must be determined. This will be a significant force, the value of which can approach the mass of the package. The chock must be constructed from a material that is able to withstand such a force and the structure to which the chock is attached must be suitable.

Anchor points and attachment point must be able to withstand the imposed loads at their applied angles and the forces imposed on the package at the attachment points must not damage the package. When chocks are used the package must be withstand the forces imposed by the chocks.

It is recommended that tie-down anchor points should be fastened directly to the frame of the conveyance and not to the platform, unless the platform is capable of withstanding the specified design forces.

Figure 2: Cuboidal package with corner ties



4.5.2. Corner Ties, Cylindrical Packages

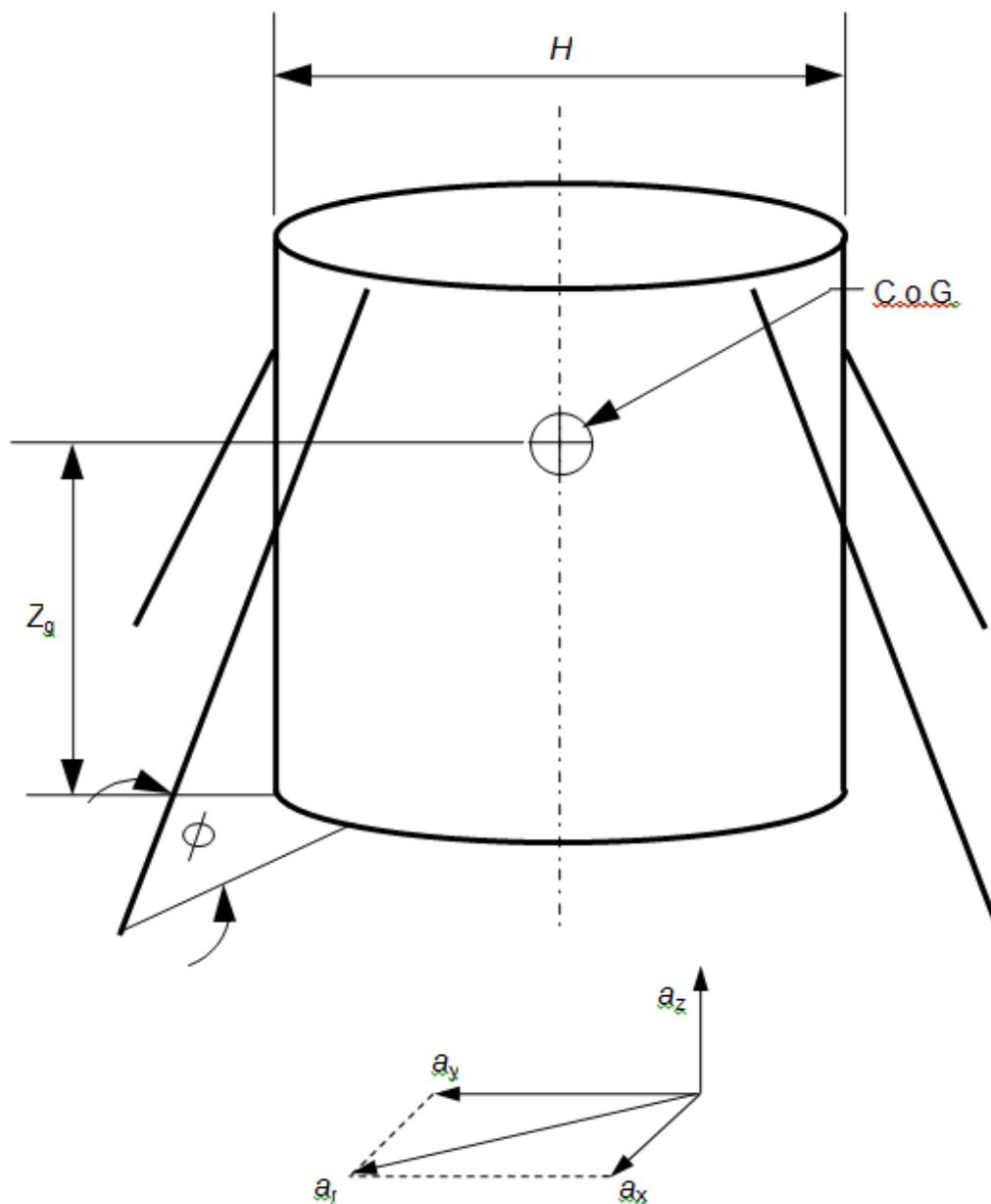
This system is shown in generalised form in Figure 3. It is strongly recommended that the package is chocked in all directions. The ties should be pre-tensioned to reduce shock loading and fatigue damage.

The tension in the tie-down members can be calculated using the same methods as for cuboidal packages.

Since there are no edges about which the package will preferentially tip, both the longitudinal and lateral accelerations will result in tensions in the tie-down members and the conservative approach outlined in paragraph 4.5.1 should be adopted.

The chock loads must be determined and the design of the chocks, attachment points and anchor points reviewed as noted in section 4.5.

Figure 3: Cylindrical package with corner ties



4.6. Directly Bolted Packages

4.6.1. Cuboidal Packages

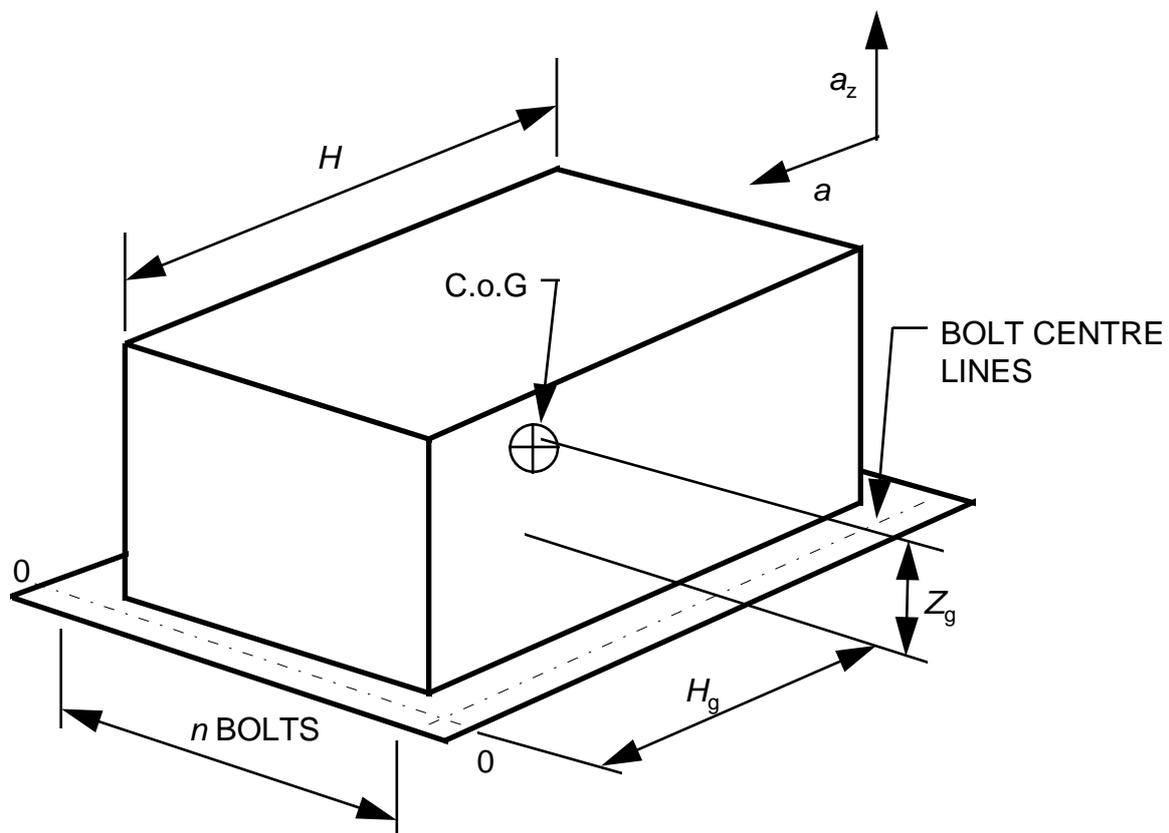
This system is shown in generalised form in Figure 4.

The maximum bolt load can be calculated from first principles by a suitably qualified engineer or by a suitably qualified stress engineer probably using finite element analysis.

The packaging is effectively fully chocked by the bolts. The sliding forces acting on the bolts on adjacent sides are $M.a_x$ and $M.a_y$ respectively resulting in a total shear load of $M.a$. Provided it can be shown that the bolt clamping force is sufficient to prevent relative movement between the base of the packaging and the vehicle bed, this shear load may be divided equally among all of the bolts. If there is relative movement then the design should be reviewed since the shear load will be applied to only one or two bolts.

A package may be indirectly retained by the use of engineered clamps which are bolted to the conveyance or to a transport frame. Similar calculations would be required to determine the maximum bolt stress.

Figure 4: Directly bolted cuboidal package



4.6.2. Directly Bolted Cylindrical Packages

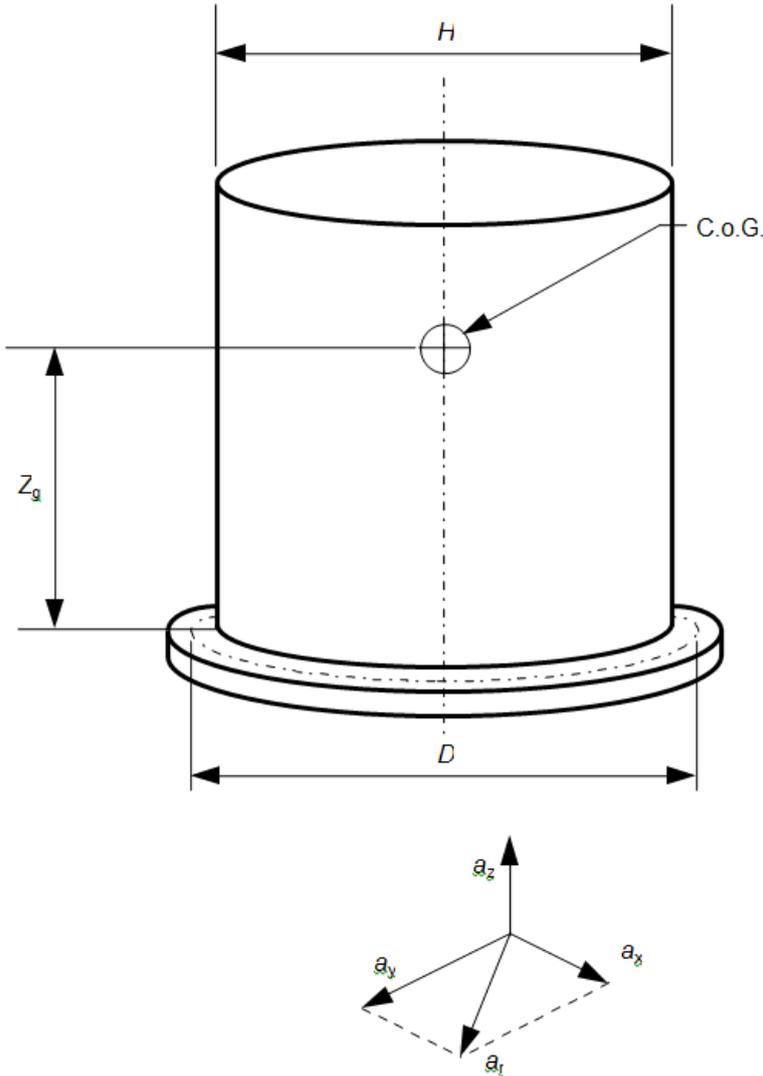
This system is shown in generalised form in Figure 5.

Compare the orientation of the package on the vehicle with the direction of the resultant acceleration a_r derived from two horizontal accelerations a_x and a_y . This will indicate the point around the package base that will act as a pivot when it tries to topple under maximum loading conditions.

The calculations to determine the bolt stresses and required bolt size are complex and should be undertaken by a suitably qualified stress engineer. This would probably be done using finite element analysis.

The packaging is effectively fully chocked by the bolts. The sliding forces acting on the bolts are $M.a_x$ and $M.a_y$ respectively resulting in a total shear load of $M.a_r$. Provided it can be shown that the bolt clamping force is sufficient to prevent relative movement between the base of the packaging and the vehicle bed, this shear load may be divided equally among all of the bolts. If there is relative movement then the design should be reviewed since the shear load will be applied to only one or two bolts.

Figure 5: Directly bolted cylindrical package



4.7. Twistlocks and UIC Spigots

With the twistlock system the corner fitting is the attachment point, the twistlock is the tie-down member and the twistlock housing (fixed to the conveyance) is the anchor point, see Figure 1. This type of system can be considered in one of two categories. Firstly, standard twistlock systems to ISO 1161 (Reference 22) such as those used on freight containers. Secondly, non-standard twistlock systems which are based on the same principles but may differ in dimensions, strength etc. It is common practice for packages which are approved as Industrial Packages Type IP-2 or Type IP-3 freight containers to be secured to the conveyance by means of standard ISO corner fittings and twistlocks or UIC spigots. The two systems are generally interchangeable, however, twistlocks may not be available on all rolling stock.

Packages which are designed as Industrial Package Types IP-2 or Type IP-3 freight containers in accordance with para. 629 of SSR-6 (Reference 1) are subjected to a number of tests as prescribed in ISO 1496/1-1990 (Reference 23). These tests ensure that the packages are suitable for international exchange and for conveyance by road, rail and sea, including interchange between these modes of transport. This includes testing to demonstrate the adequacy of the tie-down system. Hence it is not necessary to perform additional design calculations against the load conditions specified in Section 3 of this document. Where standard corner fittings, twistlocks or UIC Spigots are incorporated in other packaging's, for example Type B(U) and Type B(M), or for the attachment of transport frames the welds attaching the corner fitting to the package should be assessed in accordance with the requirements of Section 3 of this document. No justification of the corner fitting is required provided that it is a proprietary item and sized to suit the mass and geometry of the packaging.

The head of a UIC spigot is shaped to guide the container corner casting on and off the spigot during loading and unloading. UIC spigot design and locations are set out in UIC 571.4 (note that containers less than 1.6t should not be carried on spigots alone A UIC spigot that complies with UIC 571- 4 also provides overturning restraint in Routine Conditions of Transport (RCT) and Normal Conditions of Transport (NCT). The sequence and magnitude of the forces necessary to cause detachment are outside the normal extremes of wind and track conditions existing in the UK, provided the spigot geometry and spigot locations on the wagon were maintained within the limits specified by the UIC (Figure 6). The function of UIC spigots is to locate and secure to rail freight wagons, containers fitted with corner castings to UIC standard 592-2, 'Large containers for transport on wagons - technical conditions to be fulfilled by large containers accepted for use in international traffic'. Usually no further locking of the container onto the spigot is necessary, although the spigot has a 25 mm diameter hole to provide facility for a locking pin to be inserted to prevent lifting of the container should the railway administration, consignor or design authority deem it necessary in certain conditions (Figure 7). It should be noted that limited UK rolling stock is available that would provide this capability. The use of pins may be used in situations such as high winds or in order to allow the use of a weak link in the design. On some units the corner casting is blanked off thus it is not possible to secure using the pin (the addition of a pin may exceed gauge restrictions and should be carefully considered).

If non-standard corner fittings and twistlocks are used in transport packages it will be necessary to demonstrate that the entire tie-down system will withstand the load conditions specified in Section 3 of this document.

Note 1: It is not recommended that inward folding spigots are used on UK conveyances.

Note 2: The use of spine wagons is not recommended for the transport of radioactive packages.

Figure 6: UIC Spigots

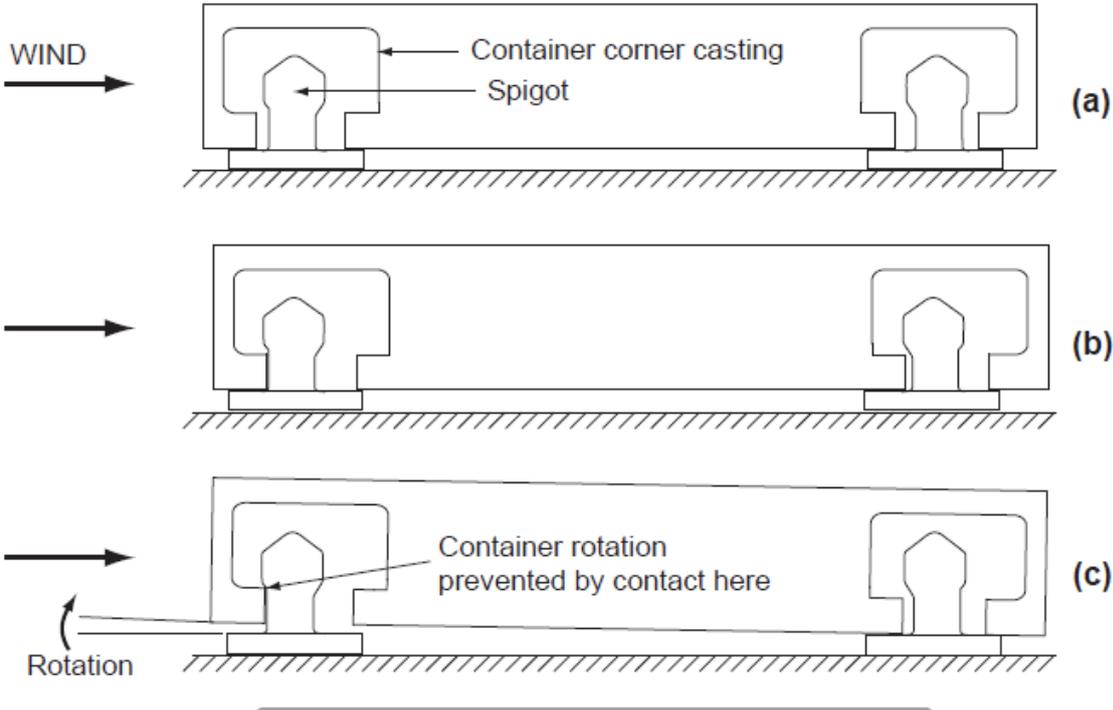
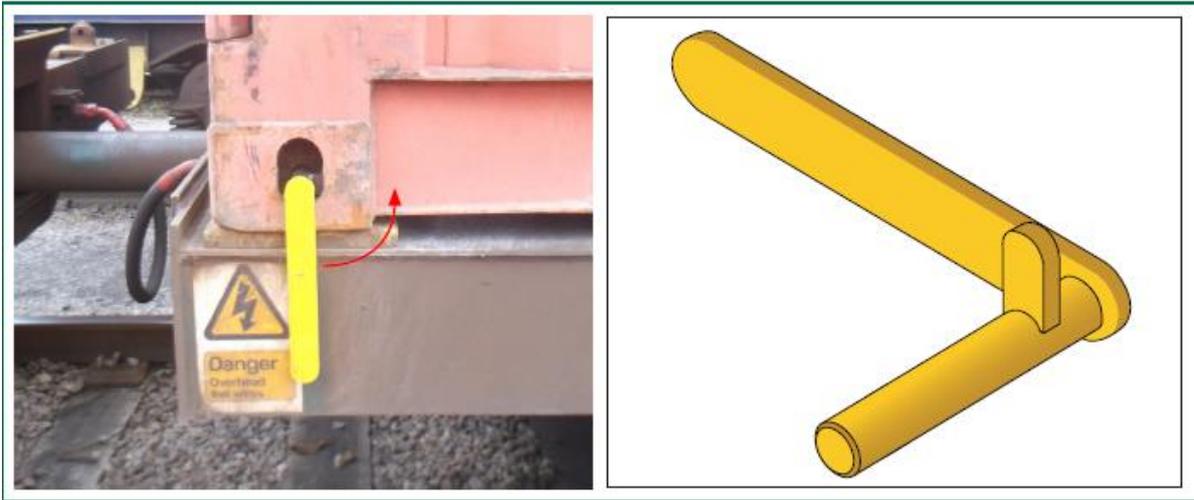


Figure 7: UIC Spigots with pin



4.8. Over Strapping

In some cases a package (or an unpackaged item) may have neither specific attachment points built into it nor a purpose built frame and is secured by positioning lashings (suitably rated webbing straps) over the top of the package and securing them to the vehicle bed. This method is also known as top-over lashing or frictional lashing and BS EN 12195-1 (Reference 21) allows the use of this method with and without chocking for general road transport. Although this method is frequently used in general transport it is less common in the nuclear industry and should be limited to packages weighing less than a few tonnes and of low radiological hazard.

Since there is no direct linkage between the ties and the load, load retention depends on friction. Tensioning of the lashings applies a downward load to the package increasing the frictional resistance to prevent the package from sliding. The tension is typically applied using standard ratchet devices which are designed to induce a known tension when operated correctly by a trained operator. Anti-slip mats with a certified friction factor and load rating should be used to increase the tension induced friction factor between the package and the conveyance platform. Although this may initially not appear to comply with the IAEA advice that “Friction between the package and the conveyance platform is to be ignored and can only be regarded as a bonus giving an additional but unquantifiable margin of safety”, it is considered acceptable where the frictional resistance is quantifiable. Where this approach is being considered for RAM transport the selection and justification of the value for the coefficient of friction is important. Appendix B of BS EN 12195-1 (Reference 21) provides typical friction factors and suggests practical ways for determining this figure, the testing needs to be sufficiently conservative to reflect all reasonably foreseeable transport conditions e.g. weather: the final value may be quite low. Untested coefficients of friction need additional conservatism. It may be that reliance on a friction argument with such a small coefficient would have a limited benefit, without including additional operational controls, such as re-tensioning during transport for loads liable to settle. However, the consequent ALARP implications on operator dose uptake during re-tensioning must be justifiable otherwise over strapping must not be used.

It should be noted that in general the use of over strapping should be limited to tie-down systems where chocks are incorporated into the design. In cases where this is not possible, for example when using a contract trailer which cannot be modified a lorry/trailer headboard/bulkhead may serve as a chock in one direction provided it is of adequate strength. Where chocking is not possible, a conservative and robust justification to use over strapping without chocking is required.

Restraint calculations must be produced to determine the quantity and rating of lashings required. Further guidance and typical formulae can be found in BS EN 12195-1 (Reference 21) however, when the formulae in BS EN 12195-1 are used the acceleration factors as combined in each line from Table 1: Acceleration factors for package retention system design (Strength Assessment) of this Code of Practice must be used.

Packages secured by over strapping must be carried on the longitudinal centre line of the conveyance since movement of an offset load towards the centre of the conveyance will result in a loss of tension in the restraint leaving the package insecure. Offset loads must always be positively restrained with the addition of chocks.

Web lashing straps must comply with BS EN 12195-2 (Reference 24). The lashings must be attached to correctly sized and rated anchor points on the conveyance (not rope hooks). For transport, lashing straps must not be joined end to end underneath the vehicle. It may be necessary to protect the package or the lashing strap from damage by the use of corner/edge protectors or protective sleeves. Care must be taken to ensure that these remain in position during transport.

Where a load that is liable to settle is being carried in a flexible or low integrity package, the tensioning of the lashings should be regularly checked during transport with the first check being made after a few miles. It may be appropriate to undertake a trial run(s) to demonstrate that such a system is suitable. Hence, use of over strapping would require a system of operational controls to support their use.

The use of over-strapping without chocking should not be used for restraining the contents within a package since access to the interior of the package to check the tensioning of the lashing is not possible during transport.

4.9. Self Retaining

It is possible for a package to be retained on a vehicle by its own mass. In practice this is seen with either very large packages weighing tens of tonnes restrained by chocks or with drums carried in stillages.

Experience has shown that for large packages, weighing upwards of 20 t, the chocks can be relatively low, say 300 mm. They must of course be sufficiently strong to resist the horizontal loads. The large mass provides sufficient inertia so that a vertical component of acceleration sufficient to dislodge the package cannot occur under Normal Conditions of transport.

Low mass packages, typically drums, are more susceptible to vehicle movement. The chocks should be extended upwards beyond the package centre of gravity, so that any toppling moment is controlled by a direct horizontal bearing force. This arrangement is typically a stillage and practical experience has shown that it operates successfully. For a package to be ejected from a stillage requires a violent short time/large amplitude motion of the conveyance which can reasonably be justified as not occurring under Normal Conditions of transport. A stillage must itself be secured to the vehicle by direct bolting, ISO corner fittings or strapping.

Since the package inertia forms the restraint, justification of the design relies on a quasi-static approach rather than a static one. The designer should aim to demonstrate that the magnitude and duration of the applied accelerations are not sufficient to lift the package out of the chocks or stillage.

4.10. Unsecured

“Unsecured” in this sense means that there is no tie-down system in use to positively secure the package to the conveyance. The package may be restrained by restricting movement of the package by the use of packing (dunnage) or systems such as restraining bars or other packages. If restraining bars are used they must be suitably rated to withstand the acceleration forces determined in section 3.3 and 3.4.

Lightweight, inherently stable packages may be transported totally unrestrained in an enclosure such as a van. Should movement of such packages occur then minimal damage will occur to other packages within the consignment or the enclosure, and the risk to the driver or the integrity of the packages is minimal. It should be noted that in such circumstances (i.e. vehicles less than 3500kg) higher acceleration values should be considered. This method of loading is effective and quick, and minimises operator dose uptake subject to adequate segregation of the packages from the driver. Packages of significantly different types, e.g. metal drums and fibreboard boxes, should not be loaded together unrestrained since in this example the drums could damage the other packages. Lightweight typically refers to packages that can be hand carried i.e. 25kg maximum. If radioactive packages are carried with other goods or handling equipment, care must be taken to ensure that the non-radioactive items cannot damage a radioactive package. If radioactive packages are carried with other dangerous goods the mixed loading restrictions in the appropriate modal regulations must be followed.

The DfT Code of Practice, Safety of Loads on Vehicles (Reference 3), notes that if goods are carried in an estate car without a bulkhead fitted to protect front seat personnel, the load must be suitably restrained. Radioactive packages carried in an estate car or similar vehicle with no bulkhead to protect the driver or other passengers should be suitably restrained noting that in such circumstances (i.e. vehicles less than 3500kg) higher acceleration values should be considered.

When carrying heavier packages or lightweight packages that are not carried in accordance with the second paragraph of section 4.10, suitable restraint methods must be applied. This may be achieved by using conventional tie-down methods as described in earlier sections or by the use of suitable packing (dunnage) or systems such as restraining bars.

Care should be taken if utilising shrink wrapping. During many years of transport operations no problems have been encountered when mixtures of shrink-wrapped pallets (up to 1000 kg), drums (80 kg) and fibreboard boxes (30 kg) have been judiciously loaded together using restraining bars.

In accordance with the DfT Code of Practice (Reference 3) packages carried in curtain-sided vehicles (commonly known as Tautliners) must be restrained. Typically restraint methods similar to those used for flatbed vehicles should be used and suitable calculations completed. The curtains of curtain-sided vehicles **should not** be considered as part of any load restraint system.

4.11. ISO Containers Used as Overpacks

Packages carried in standard Cargo Transport Units (CTU) e.g. an ISO freight container, must be restrained to prevent movement within the unit. Purpose designed tie-down systems may be used. or movement may be restricted by the use of packing (dunnage) or systems such as restraining bars may be utilised.

When restraining packages within standard CTUs the container doors shall not be used to restrain the contents. The load shall be reacted onto the main structure of the container. In the door area of the container this is the corner posts. An example of this is the use of a purpose built frame that reacts the load to the door frame when transporting drums.

The payload can be restrained by other packings or adequate dunnage or restraining bars. This would apply particularly when the payload comprises a number of items. If dunnage is used to prevent contents from moving within a container it must be suitable - air filled dunnage bags are not considered suitable.

4.12. Weak-Link

The IAEA regulations make reference to the possibility of including a Weak Link. The design of a Weak Link within the Tie-Down system is hard to achieve given that it is difficult to design something to fail at a given point and accident conditions have many variables.

Typically where a weak link is included it should be designed to fail at an appropriate margin between NCT and ACT. One means of achieving this is for the designer to choose an acceleration value between the RCT accelerations in

Table 1 and the acceleration values for which the package is assessed at (typically as per the mechanical tests in Section 727).

The designer should then ensure that a hierarchy of failure is achieved such that the package will detach from the transport frame or conveyance before the full loads calculated in accident conditions of transport are achieved. The Weak Link design method will be influenced by the predicted ACT scenario and resultant load paths.

Methods of achieving the weak link could be as follows:

- Necked down section – A portion of the tie-down system could be necked down to give a tensile failure point that would fail before other sections of the tie-down system as discussed above.
- Shear Pins – Shear pins could be used which would shear at a known load prior to any of those in other section of the tie-down system,
- Necked down bolt – A necked down bolt could fail at a given load. The advantage of a necked down bolt is that the bolt can be easily replaced.

It is important to select materials where accurate Ultimate Tensile Strength (UTS) values can be achieved as failure as a predictable failure range is required. Dependent on the NCT loading it is also important to consider the fatigue load case for the weak link, as the weak link may require replacement after a certain number of cycles in order to mitigate the risk of fatigue failure.

5. Use of Tie-Down Systems

5.1. Operation

The tie-down system must be used in the way that the designer intended and inspected at regular intervals to ensure that it is still capable of withstanding the design loads.

The staff who operate the package must be provided with clear instructions on how to restrain the contents within the package. The staff who operate the conveyance must be provided with clear instructions on how to restrain the package to the conveyance.

These instructions do not necessarily need to be an extensive stand-alone document. The following information should be included

- a) A schedule of the equipment that forms the tie-down system.
- b) If standard equipment such as shackles, webbing straps etc is used, the rating of each item must be given.
- c) If the vehicle is dedicated to the transport of this particular package it should be clearly identified.
- d) If a general purpose vehicle is to be used then its load carrying capability must be specified together with the position and rating of any anchor points.
- e) The tightening torque and tightening sequence of hold-down bolts should be specified.
- f) If a number of packages are loaded on a single conveyance, a loading sequence may be required. The vehicle loading should be considered to ensure that the vehicle bed is not locally over stressed or permitted axle loadings exceeded.

5.2. Inspection

Tie-down equipment should be inspected and where appropriate be the subject of regular maintenance. The work required and the frequency that it is carried out is specified by the designer and should reflect the duty cycle and the hazard presented by the package contents. The following are recommendations for good practice:

- a) Attachment points should be regularly inspected as part of the packaging maintenance procedures.
- b) Dedicated tie-down members should be regularly inspected as part of the packaging maintenance procedures.
- c) Proprietary tie-down equipment should be checked before use. Lashing straps should be inspected to ensure the webbing is not cut or frayed and that a BS EN 12195-2 label is fitted.
- d) When dedicated conveyances are used, anchor points should be registered on a maintenance schedule and inspected at regular intervals in accordance with regulatory requirements. When conveyances are hired in anchor points should be inspected to ensure they are in good condition and suitably rated for the job.
- e) Standard equipment such as shackles and eyebolts should be registered and inspected at regular intervals in accordance with regulatory requirements.
- f) There should be written procedures for inspection work and records of when it was carried out and by whom. These records should be retained and should detail any repairs that have been carried out.

6. Restraint of Payload/ Package Contents

6.1. General Remarks

The payload refers to the radioactive contents of a package. Many packages are designed and if necessary tested with a specific payload so that the payload is restrained in a set position within the package or the package is designed to withstand movement of the payload. If this is not the case it will be necessary to restrain the payload within the package to prevent damage to the package during transport.

The same provisions apply to the restraint of the payload within the package as apply to securing the package to the conveyance and all design requirements of package restraint systems equally apply to internal restraint systems (package furniture) for contents. The methodology is as described in section 3.

Appropriate restraint systems are typically as listed in Section 4 as follows:

Trunnion

Trunnions on the item are secured to bearers that form part of the packaging.

Corner ties

Lashings are connected between attachment points on the item and anchor points within the packaging.

Directly bolted

The item is bolted directly to the internal structure of the packaging or/and package internal frames are designed and manufactured to enable direct bolting of the contents to the package cavity.

Strapping

Lashings are positioned over the top of the item and secured to the internal structure of the packaging. This method may not be suitable since regular checking of lashing tension is recommended and may not be possible.

Unsecured

The payload is restrained by packing/dunnage or restraining bars. This would apply particularly when the payload comprises a number of items.

6.2. ISO Freight Containers

Although ISO freight containers may be used as overpacks to transport packages, they may also be used as Type IP-1 or as Type IP-2/IP-3 packages in accordance with the alternative requirements of the IAEA Transport Regulations (Reference 1). Although the ISO type approval tests require a certain wall strength, the contents could damage or puncture the container walls if not restrained. Further details on the requirements for the use of ISO freight containers as IP-2 packages can be found in TCSC 1090 (Reference 25).

General guidelines applicable to the restraint of radioactive contents within freight containers, when used as approved IP-1 or IP-2 Packages are as follows:

- All items shall be placed in the container in such a manner that significant movement of the contents cannot occur. If movement of the contents could occur restraint systems should be considered.

- Any contents which have the ability to penetrate the container walls during normal conditions of transport must not be loaded adjacent to the internal surfaces of the container.
- Where large and/or heavy items are carried, they should be located centrally within the container and chocked/restrained to prevent any movement under normal conditions of transport.
- The contents should be evenly distributed across the floor area of the container and in no case should more than 60% of the load be in less than half the length of the container. A load spreading frame may be required to ensure that the floor loading limit is not exceeded.

The freight container must be able to withstand the loads applied by the payload restraint system. This may require that the base of the container is specially designed for bolted loads or frames. Anchor points for tie-down restraints must be placed so there is a load path into the container frame. They must be suitable for the applied loads and calculations produced to justify the loadings on the anchor points.

If dunnage is used to stop contents from moving within a container it must be suitable for the load of the container. Air filled dunnage bags are not generally considered suitable for the transport of radioactive materials.

If necessary a loading plan should be prepared detailing the location of the payload items within the container and the restraint arrangements.

When restraining items within a double door ISO container the container doors shall not be used to restrain the contents. The load shall be spread to the main structure of the container, in the door area of the container this is the corner posts. An example of this is the use of a purpose built frame that spreads the load to the door frame when transporting drums.

6.3. Other Package Designs

For other large packages (e.g. boxes carrying contaminated equipment or decommissioning components) the requirements as listed for ISO freight containers would generally apply.

In smaller packages the payload restraint will usually form part of the packaging or no restraint will be required. If restraint is required this may often be achieved by the use of suitable packing materials.

7. Transport Frames

A Transport Frame is a dedicated means of attaching a specific package to a conveyance and should be treated as a tie-down member.

7.1. General

Concern has arisen internationally as to whether a tilt frame or transport frame carrying a flask is effectively part of the package design. The implication is that if the frame is part of the package design it should be attached to the package during the design impact testing.

The reasoning is that if the restraint should fail in an accident (as would be expected) the transport frame may remain attached to the package and the assembly subjected to any resultant impact. If that is the case the transport frame should be attached to the package during testing. To avoid this requirement, it is therefore desirable that during an accident the package/flask should detach from the transport frame which remains attached to the conveyance. Paragraph 638.1 of SSG-26 Draft suggests the use of a designed weak link in the attachment point or tie-down member which fails in the event of an excess load being applied. The weak link design has been discussed in section 4.12 of this document.

Proposals of this nature should be discussed and agreed with the appropriate Competent Authority.

8. Heavy Loads

8.1. General

The transport of heavy loads, particularly where the mass of the package exceeds that of the conveyance (such as large fuel flasks) may require special consideration. When considering lateral accelerations, the lateral forces may cause the vehicle to overturn before the calculated tie-down load is reached. For example a typical 116 tonne flask carried on a rail wagon would overturn when subjected to a lateral acceleration of 0.32g (Reference 26), well below the factor of 0.5g (from Table 1) which is normally used. The restrictions applied to the transport of loads of this type, under both routine and normal conditions of transport, are such that in practise overturning would not occur.

If reduced acceleration factors were used taking note of the mass and geometry of the conveyance, the required strength and hence size and mass of the transport frame may be reduced. This could make an appreciable difference when heavy loads are considered. Similar considerations may apply to road transport.

Proposals of this nature should be discussed and agreed with the appropriate Competent Authority.

9. References

1. IAEA Specific Safety Requirements: Regulations for the Safe Transport of Radioactive Material, 2018 Edition, Revision of IAEA Safety Standards Series No. SSR-6 (Rev 1)
2. IAEA DS496 Draft Safety Guide: Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (20XX Edition), Revision of SSG-26, 2012 Edition
3. DEPARTMENT FOR TRANSPORT. Code of Practice. Safety of Loads on Vehicles. Third Edition.
4. EUROPEAN COMMISSION. European Best Practice Guidelines on Cargo Securing for Road Transport.
5. UNITED NATIONS. Recommendations on the Transport of Dangerous Goods. Model Regulations. Nineteenth revised edition. ST/SG/AC.10/1/Rev. 19.
6. ONR GUIDE. TRA-PER-GD-014 Revision 1, Guidance for Applications for UK Competent Authority Approval, July 2016.
7. TRANSPORT CONTAINER STANDARDISATION COMMITTEE. Self Assessment and Approval of Package Types IP-1, IP-2, IP-3 & Type A. TCSC 1078. May 2013.
8. BRITISH STANDARDS INSTITUTION. Rules for the design of cranes. Part 1: Specification for classification, stress calculations and design criteria for structures. BS 2573-1:1983.

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